## EXECUTIVE SUMMARY

This Phase II Accreditation Support Package (ASP-II) is intended to provide users of the EADSIM model with confidence that outputs resulting from valid ranges of inputs should be reasonably valid representations of real world conditions and outcomes. The overall objective of ASP-II activities is the identification of that set of problems for which EADSIM is expected to produce reasonable results (the application domain) as well as those functional elements (FEs) that are critical to model level measures of performance (MOPs) and are, therefore, potential targets for detailed V&V efforts. V&V activities that contribute to meeting this objective are divided into two categories:

**Logical Verification**, which ensures that the basic equations, algorithms, and design of the model are reasonable and correct, and which identifies assumptions and limitations inherent in the implementation; and,

**Face Validation**, which consists of input data verification and validation, comparison of model outputs with intelligence data and known or best estimates, and a review of sensitivity analysis results.

ASP-II documentation provides software design information in the Conceptual Model Specification (CMS) that supports *Logical Verification* and Sensitivity Analysis Reports (SARs) that support *Face Validation.* When coupled with ASP-I information, ASP-II provides the user with the best available confidence level in model results short of detailed, total model V&V, which is addressed in Phase III.

Results of logical verification include characterizations of model functionality that do not agree exactly with the known physical world. These are classified as either assumptions or limitations and are manifested in either an individual FE or in the model as a whole (two or more FEs). Model level assumptions and limitations and those for specific FE are listed in Tables i-1 through i-4. These were derived from conceptual model specifications, which are equivalent to software design documents that were reverse engineered from existing code. These assumptions and limitations may impact model use to the extent that they affect certain aspects of intended applications. Detailed descriptions of their aspects and implementations are provided in the CMS section (2.0) for each FE addressed thus far.

TABLE i-1. *EADSIM* Model Level Assumptions.

| Functional Element | Assumptions | Conditions of Applicability |
|---|---|---|
| Platform Movement | • Lateral forces on aircraft during straight line flight are not modeled.<br>• Lateral forces are balanced during coordinated steady turns<br>• Ordnance weight is included as part of the vehicle's weight and is never decremented.<br>• Aircraft signatures are decremented at weapon launch<br>• Aircraft flight propagation includes no angle of attack sensitivities<br>• Aircraft propagation uses a 3 DOF flight model and assumes a point mass propagated through space<br>• Turns are performed at corner speed assuming max Gs if the A/C is not in CAP, or 3 Gs if it is in CAP<br>• Drag and Engage modes use target truth position rather than track measurements in setting the direction of flight<br>• AR Tanker flight speed does not account for receiver speed limitations | Always |
| Decision Making Elements | • Local sensor are assumed to be cued to a track when a Commanded Assignment message containing a sufficient data quality rating is received at the sensor. | • Flexible SAM Ruleset |
| | • The engagement throughput loading of a SAM system is assumed to be manageable as a function of the number of engagements/assignments over an interval of time. | • Applies to all tracks in the target select phase of the Flexible SAM Ruleset. |
| | • A target that is known (through received messages) to be engaged by another platform is assumed to be unavailable for engagement. Intentional dual engagements are modeled (time to last launch overrides that allow last shot opportunities by lower tier systems have been added to version 5.00). | • Flexible SAM Ruleset in version 4.01. |

TABLE i-1. *EADSIM* Model Level Assumptions. (Contd.)

| Functional Element | Assumptions | Conditions of Applicability |
|---|---|---|
| Decision Making Elements (Contd) | • SAM systems are incapable of engaging ground targets | • Flexible SAM Ruleset. |
| | • SAM systems generate CANTCO messages if they are unable to respond to an engagement command within a specified period of time. | • Flexible SAM Ruleset. |
| | • SAM systems assume that a collocated or local sensor with sufficient quality must be tracking a target in order to launch a weapon against it. (Version 5.00 includes the capability to launch weapons using information external or remote sensors with sufficient quality to support engagements in a coordinated manner) | • Flexible SAM Ruleset in version 4.01. |
| | • SAM systems are assumed to require a local impact point prediction before they can evaluate ballistic missiles as threats. | • Flexible SAM Ruleset. |
| | • A SAM is assumed to have engagement authority when it is operating in autonomous mode. User inputs determine whether a SAM will attempt engagements in each mode. | • Flexible SAM Ruleset. |
| | • An ABT (aircraft or cruise missile) that is receding from an asset is assumed to be non threatening to the asset. | • Such targets can be engaged if the SAM is operating in a zone or area defense mode or if the target is approaching another asset. |
| | • Track Establishment does not rely on sensor measurements after the first detection (the M out of N modeling allows intermittent returns). | • This limits the ability to represent the difficulty in establishing track on Low Observable (LO) aircraft. |
| | • Ground based platforms (such as SAMs) cannot launch another platform for a detailed representation of surface launched cruise missiles or other smart munitions. | |

TABLE i-1. *EADSIM* Model Level Assumptions. (Contd.)

| Functional Element | Assumptions | Conditions of Applicability |
|---|---|---|
| Battle Management and Message Processing | Note: Battle Management decisions are modeled as a series of phases of operations<br>• The execution of a decision phase is assumed to represent the decisions made since the phase was last scheduled for execution.<br>• The knowledge of engagement activities of other platforms is assumed to be available only through messages received over the communications networks. | • Applies to all rulesets<br>• Applies to all rulesets |
| Message Processing | • Messages are modeled at the functional level, including: message type, transmit time, baud rate, message size<br>• Messages of the same priority are assumed to be handled through a FIFO queue on transmission and reception over a given network.<br>• Message traffic is assumed to be limited by communications link baud rate for data protocols and time for voice protocols.<br>• Messages are assumed to be received in total or not received at all. Reception is based on signal to noise ratio (SNR) | |

TABLE i-2. *EADSIM* Model Level Limitations.

| Functional Element | Limitations | Conditions of Applicability |
|---|---|---|
| Platform Movement | • Aircraft flying in formation with tankers during Air Refueling operations have limited defensive reactions.<br>• An interceptor missile cannot be diverted to an alternative target after it has been launched. | Always |
| 2.1 Sensors | • All detections are assumed to be constrained by a common set of requirements:<br>- Sensor platform and target are active<br>- The target is within the sensor's FOV<br>- The LOS between the target and sensor is not blocked by terrain | Sensors include IR, radar, HUMINT, IMINT, SIGINT, Launch Detection and Passive RF (Passive RF applies to version 5.00 only) |

TABLE i-2. *EADSIM* Model Level Limitations.

| Functional Element | Limitations | Conditions of Applicability |
|---|---|---|
| 3.2.1.1 Radar | • Detections can be probabilistic or deterministic. Probabilistic detections are a function of SNR. Deterministic detections compare SNR to a threshold. | • Ground target detections are modeled probabilistically. Airborne targets can be modeled probabilistically or deterministically. |
| | • SNR is computed from the radar range equation. The receiver can be an ideal matched filter or the user can specify a receive processing loss. | • Radar detection of airborne targets. |
| | • Peak SNR is used for all calculations. | • Radar detection of airborne targets. |
| | • Radar resource management is a function of occupancy and duty cycle only; it does not model pulse scheduling. | • Radar detection of airborne targets. |
| | • Non-coherent pulse integration supports Swerling 0 through Swerling 4 target models. | • Radar detection of airborne targets. |
| | • Coherent integration is assumed for Swerling 0, 1 and 3 targets. | • Radar detection of airborne targets. |
| | • Coherent gain is not applied to Swerling 2 and 4 targets. | • Radar detection of airborne targets. |
| 3.2.1.4 Passive RF | Detection is probabilistic | Applies to ARM targeting decisions, jamming decisions and general signal intelligence collection. |
| 3.2.1.1 Radars | • Propagation factors for computing SNR are point values independent of radar/target location. (The addition of multipath/diffraction and atmospheric model to version 5.00 nulls this statement). | • Applies to version 4.01 |
| | • The detailed antenna model for phased array antennas does not represent the changes in sidelobe gains and shapes caused by beam pointing. | |
| | • Antenna polarization is limited to vertical and horizontal. | • Circular and elliptical polarizations cannot be represented |
| Connectivity | • Relay nodes for command messages are not represented | |
| | • Antenna patterns on communications devices only allow main beam jamming of a device (ongoing work allows detailed antenna patterns) | |
| Message Processing | • EADSIM does not include the capability to model processing resource utilization fro received messages | |

TABLE i-3. *EADSIM* Model Level Errors.

| Functional Element | Error | Effects |
|---|---|---|
| Platform Movement | The calculation of the beam maneuver dive angle is an approximation that assumes an angle can be halved by halving the sine of the angle. | No significant effects result from this error. The computation is only used to determine the signs of the beam vector components. |

Sensitivity analyses were performed for several functional elements (FEs) and are described in Section 3. The goal of the sensitivity analyses was to determine relative model-level sensitivities for the FEs examined in a fairly complex, many-on-many scenario. Rather than developing a new scenario, the Demo300 scenario which is distributed with EADSIM was used. All data in this scenario represent notional capabilities rather than actual system capabilities and are unclassified.

Various measures of effectiveness (MOEs) can be used to evaluate mission-level force effectiveness and are chosen on the basis of the specific analysis problem that is being studied. The most common mission-level MOE is platform attrition, but since this measure aggregrates numerous interactions and system capabilities, there is often little sensitivity to variations in many of the individual scenario characteristics. The attrition of red aircraft by blue surface and air platforms in the Demo300 scenario was chosen as the primary mission-level MOE; however, several additional, FE-specific MOEs were also evaluated.

A summary of FEs examined and the parameters varied for each are listed in Table i-4. Model-level sensitivity was based upon red aircraft attrition in the unclassified Demo300 scenario and are categorized as high, medium, or low (H, M, or L). Specific FE conclusions are summarized in the following paragraphs.

TABLE i-4. Summary of Sensitivity Analyses for EADSIM.

| FE Name | Parameter | Range Varied | Model Sensitivity |
|---|---|---|---|
| RF Sensor | Power | 21-60 dBW | M |
| | Frequency | 3.5, 6.0 GHz | L |
| | Side/Back-lobe Gain | -10/-20 to -30/-40 dBi | M |
| | Target RCS | 10-0.001 sq. m. | M |
| Weapon | Range | 10-30 km | L |
| | Velocity | 600-1600 m/s | L |
| | Pk | 25, 50, 75% | M |
| Ruleset | Max Assessed Threats | 5-20 targets | L |
| | Repeat Time | 10-120 sec. | L |
| | Assignment Options | Air Over Ground: on/off | L |
| Network Protocol | Field Length | 32-128 bits | L |
| | Message Size | 2-100 words | L |
| | Purge Time | 15, 60 sec. | L |

**RF Sensor**: The general trends in detection range as a function of the radar characteristics varied were consistent with a correct implementation of the radar range equation. No anomalies were noted that would impact model credibility in the area of RF sensor modeling.

**Weapons**: Of the three weapon element parameters varied, only weapon Pk was found to have any significant impact on platform attrition.

**Decision-Making Elements (DMEs)**: Only the Flexible Commander Ruleset was investigated in the DME sensitivity analysis, and none of the ruleset characteristics varied had any significant impact on platform attrition.

**Network Communications**: Significant sensitivity in the average number of messages received was observed for variations in message size with the ATDL1 protocol, and this FE is expected to be critical for analysis applications involving integrated command, control, and communications. In spite of this sensitivity; however, the overall platform attrition showed no significant sensitivity to any of the network parameters varied in the Demo300 scenario.

Table i-5 identifies the individual Conceptual Model Specification (CMS) sections and Sensitivity Analysis Report (SAR) sections included in this version of the *EADSIM* ASP-II.

TABLE i-5. Functional Element Cross Reference Matrix.

| FUNCTIONAL AREA | # | FUNCTIONAL ELEMENT | 2.0 CMS | 3.0 SAR |
|---|---|---|---|---|
| **Platform Aircraft/SAM/TBM** | | | | |
| | | 1.0 Attributes | | |
| | **1** | 1.1 Configuration | | |
| | **2** | 1.2 Movement | 2.2 | |
| | | 1.2.1 Propulsion | | |
| | | 1.2.2 Aero/kinematics | | |
| | **3** | 1.3 Signatures (EO/IR/RF/UV) | 2.3 | 3.3 |
| | | 1.3.1 Static | | |
| | | 1.3.2 Dynamic | | |
| | **4** | 1.4 Vulnerability | | |
| | | 2.0 Sensors | | |
| | **5** | 2.1 Radio Frequency | 2.5 | 3.5 |
| | **6** | 2.2 Infrared | 2.6 | |
| | | 2.3 Electro-optical | | |
| | | 2.4 Acoustic | | |
| | | 3.0 Weapons | | |
| | **7** | 3.1 Guided | 2.7 | 3.7 |
| | | 3.1.1 Air-to-Air | | |
| | | 3.1.2 Air-to-Surface | | |
| | | 3.1.3 Surface-to-Air | | |
| | | 3.1.4 Surface-to-Surface | | |

TABLE i-5. Functional Element Cross Reference Matrix. (Contd.)

| FUNCTIONAL AREA | # | FUNCTIONAL ELEMENT | 2.0 CMS | 3.0 SAR |
|---|---|---|---|---|
| | | 3.2 Ballistic | | |
| | | 3.2.1 Guns | | |
| | | 3.2.2 Bombs | | |
| | **8** | 4.0 Comm Devices | | |
| | | 4.1 Analog (Voice) | | |
| | | 4.2 Digital (Data) | | |
| | | 5.0 CM/CCM | | |
| | **9** | 5.1 Jammer | 2.9 | |
| | **10** | 5.2 AntiWeapon | 2.10 | 3.10 |
| | | 6.0 Decision Making Elements | | |
| | **11** | 6.1 Rulesets | 2.11 | |
| | | 6.1.1 BM Phase | | |
| | | 6.1.2 Message Processing | | |
| | | 6.1.3 Track Processing | | |
| | **12** | 6.2 Asset/Target List | | |
| **Environment** | | | | |
| | **13** | 1.0 Atmospheric | 2.13 | |
| | | 1.1 Attenuation | | |
| | | 1.2 Refraction/Ducting | | |
| | | 1.3 Radiance/Transmittance | | |
| | **14** | 2.0 Topographic | 2.14 | |
| | | 2.1 Clutter | | |
| | | 2.2 Multipath/Diffraction | | |
| | | 2.3 Masking | | |
| **Command Control and Communications ($C^3$)** | | | | |
| | **15** | 1.0 Command Chain Hierarchy | 2.15 | |
| | | 1.1 Participating Platform | | |
| | | 1.1.1 Commanding Unit | | |
| | | 1.1.2 Flight Leader | | |
| | | 1.1.3 HomeBase | | |
| | **16** | 2.0 Network Communications | 2.16 | 3.16 |
| | | 2.1 Message Transmission and Reception | | |
| | | 2.2 Network Connectivity | | |
| | | 2.3 Participant Comm Devices | | |
| | **17** | 3.0 Areas of Interest/Responsibility | 2.17 | |